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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE: HEAT EXCHANGER ASSEMBLY

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BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a heat exchanger in a coolant circuit of a motor vehicle and system to heat the passenger compartment.

2. Related Art

[0002] The trend towards highly efficient motor vehicle drive systems has resulted in a lack of sufficient waste heat for heating the interior of the vehicle. Therefore, the comfort conditions get worse in vehicles in which the passenger compartment is heated solely based on the engine's coolant circuit.

[0003] In the state-of-the-art there are many approaches to solve this problem. For example, the cooling circuit can be electrically heated or the air of the vehicle interior can be directly heated by means of PTC resistors. Additionally, fuel-fired supplemental heating devices for the coolant circuit are known.

[0004] An alternative development to supplemental heating devices is to use the refrigerant systems, or air conditioning units, present in motor vehicles for the heating of the vehicle interior. This is possible by operating the air conditioning unit as heat pump. Alternatively, a "short" circuit, without secondary heat absorption in the clockwise-rotating version or anticlockwise-rotating version, can be used. In a short circuit, essential portions of the mechanical drive power of the compressor are transformed into heat for the purpose of heating the passenger compartment. Such air conditioning units are also known.

[0005] When an air conditioning unit in a vehicle is used for additional heating, a highly undesirable effect occurs under certain use and environmental conditions.

Particularly, when the refrigerant system is used as a cooling plant, the evaporator arranged in the ventilating system of the vehicle will dehumidify the air to be cooled. After having stopped the engine and starting it anew when the heat exchanger has previously been used as evaporator and now is subsequently used as condenser or gas cooler in heating modes, due to heat being given off to the air flow, the humidity condensed on the evaporator surface will be introduced into the vehicle interior. Alternating use of the system as cooling plant and heat pump is quite frequent in the transitional weather periods, such as Spring and Autumn.

[0006] The high humidity air led into the vehicle interior results in condensation on the cold interior surfaces of the vehicle, particularly on the windows, with accompanying deterioration of the passengers' sight. This effect is also called flash-fogging.

[0007] In the state-of-the-art, solutions exist that are intended to prevent this effect.

[0008] After a special form of construction for the refrigerant carbon dioxide, in DE 198 55 309 an additional heating device for vehicles is disclosed. Here the gas cooler, or condenser, respectively, is divided into different regions, alternatingly used for cooling or heating. First, there is an evaporator region, which in cooling plant operation cools and, accordingly, dehumidifies the air flowing into the vehicle interior. Second, another region, in heat pump operation, heats the air flowing into the vehicle interior. This functional separation ensures that the air condensed on the evaporator will not, or only a little, be re-absorbed by the air flowing into the vehicle interior, thereby reducing possibility of flash fogging.

[0009] In DE 198 55 309, the heating heat exchanger is combined with the additional heating device from the refrigerant circuit for heating in such a way that the heat exchangers are switched in series. However, this results in the disadvantage that even more of the limited space available in the ventilation plants of motor vehicles is required by such a series connection.

[0010] Therefore, it is the objective of the invention to provide a heating heat exchanger, which requires little space and enables an advantageous control behavior and lowest possible flow resistance.

BRIEF SUMMARY OF THE INVENTION

[0011] According to the invention, the problem is solved by a heating heat exchanger in a coolant circuit for vehicles, whereby the air to be heated can be additionally heated by means of a refrigerant circuit operable as heat pump or short circuit to provide the additional heating. A gas cooler/condenser for the additional heating and a functionally separated evaporator for cooling plant operation of the refrigerant circuit are provided, whereby the heat exchanger surfaces of the gas cooler/condenser for additional heating operation are integrated into the heating heat exchanger and the air to be heated during additional heating operation is simultaneously heated by the heating heat exchanger and the gas cooler/condenser.

[0012] As used herein, additional heating operation means that operational mode, in which the refrigerant circuit, e.g. operating in a heat pump circuit or a short circuit, is used for additional heating of the vehicle's passenger compartment.

[0013] The combination of the invention is realized with particular advantage, when the refrigerant circuit and the coolant circuit in additional heating operation are controlled such that the heat exchanger surfaces of the heating heat exchanger and

the gas cooler/condenser have differences in temperature of less than 25 K during the additional heating operation.

[0014] One aspect of the invention is in the separation of the functions of the heat exchangers in additional heating operation and the integration of the component for the heating of the air into the heating heat exchanger of the coolant circuit.

[0015] Advantages include, without limitation, the avoidance of the flash-fogging and the possibility to space-savingly realize functional separation in heat exchanger components of the refrigerant circuit.

[0016] The combined use of the heat exchanger surfaces of coolant circuit and refrigerant circuit in the heat exchanger enables the invention to obtain the functionality of additional heating by means of a switched-over refrigerant circuit without additional space demand in a ventilating plant and without the risk of flash fogging.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Other details, features and advantages of the invention ensue from the following description of embodiment examples with reference to the accompanying drawings. The figures show:

[0018] Fig. 1 – schematic of the refrigerant and coolant circuit combination;

[0019] Fig. 2 – heating heat exchanger with integrated gas cooler/condenser;

[0020] Fig. 3 – collector unit;

[0021] Fig. 4 – collector unit with integrated refrigerant collector;

[0022] Fig. 5 – collector unit with externally arranged refrigerant collector;

[0023] Fig. 6 – gas cooler/condenser-heat exchanger component in comb design;

[0024] Fig. 7 – heating heat exchanger with integrated gas cooler/condenser in three-dimensional view.

DETAILED DESCRIPTION OF THE INVENTION

[0025] In Fig. 1 the concept of a refrigerant and coolant circuit combination is schematically illustrated. A heating heat exchanger 3 of coolant circuit 1 and gas cooler/condenser 4 of a refrigerant circuit 2 are combined such that the heat exchanger surfaces of the heating heat exchanger 3 and the gas cooler/condenser 4 are simultaneously passed by the air to be heated 5 in heat pump operation. The undesired mutual influence of the coolant and refrigerant circuits 1, 2 is minimized in that the circuits are controlled without significant power loss such that the temperature difference between the heat exchanger surfaces is less than 25 K.

[0026] Fig. 2 shows a heating heat exchanger 3 with integrated gas cooler/condenser. The heating heat exchanger 3 includes coolant tubes 6 and refrigerant tubes 7 alternatingly arranged side by side, which are parallelly passed by the air to be heated. Between the coolant tubes 6 and refrigerant tubes 7 cellular blocks 11 are provided, which enlarge the heat exchanger surface. In the example of embodiment shown the coolant and refrigerant collector regions 9, 10 are placed at the heat of the heating heat exchanger 3. The term collector, or collector region, respectively, is, with the corresponding function in reversed sense, also meant as distributor, or distributor region, respectively, without special reference.

[0027] In the example shown, the coolant and similarly the refrigerant of the coolant circuit 1 are distributed in the coolant collector region or coolant distributor

region 9 of the distributor unit into the coolant tubes 6, pass the coolant tubes 6 dissipating heat to the cellular blocks 11 in thermal contact with the coolant tubes 6 and the air to be heated 5. In the redirection region 14 of the coolant tubes 6 it is redirected by 180° and flows in opposite direction back to the coolant collector region 9, where the coolant is collected and passed on. The 180° redirection of the refrigerant takes place similarly in the helix-shaped redirection region 12 of the refrigerant tubes 7.

[0028] In Fig. 3 a collector unit 8 for a heating heat exchanger 3 with separate collector and distributor units is shown. The collector unit 8 has a coolant collector region 9 and a refrigerant collector region 10 with the refrigerant collector region 10 partly surrounded by the coolant collector region 9. The coolant tubes 6, configured as flat tubes, lead into the coolant collector region 9 of the collector unit 8. The refrigerant tubes 7, configured as flat tubes with channels for the refrigerant, penetrate the coolant collector region 9 and lead into the refrigerant collector region 10, which is separated from the coolant collector region 9, within the collector unit 8. According to the shown preferred embodiment of the invention, two layers of coolant tubes 6 and refrigerant tubes 7 are provided in each case, whereby the refrigerant tubes 7 are only arranged within one layer of the coolant tubes 6.

[0029] The Figs. 4 and 5 represent different embodiments of the design of the collector unit 8. In Fig. 4 a collector unit 8 with refrigerant collector region 10 integrated into the coolant collector region 9 is shown. In Fig. 5, an embodiment of a collector unit 8 is shown, the refrigerant collector region 10 of which is arranged outside of the coolant collector region 9.

[0030] From the above, a concept is realized, in which the refrigerant collector region 10 has no common boundary surface with the coolant collector region 9 and, hence, is thermally separated from it located outside of the coolant collector region 9. Thus an undesired heat flow from the coolant circuit 1 to the refrigerant circuit 2 and vice versa is prevented. In the shown embodiment of the invention, the refrigerant tubes 7 penetrate the coolant collector region 9. An advantageous modification of the invention consists in the refrigerant tubes 7 being installed in a wider arc around the coolant collector region 9 and therefore no direct thermal contact through heat conduction to the coolant collector region 9 exists.

[0031] In Fig. 6 another advantageous embodiment, characterized by a comb design, is shown. The heating heat exchanger 3 is configured as usual in the state-of-the-art modified in that some coolant tubes 6 are omitted to make space for refrigerant tubes 7. The refrigerant collector region 10 are connected to the refrigerant tube 7 over connection tubes 13. Due to the fact that the refrigerant collector regions 10 are arranged outside of the coolant collector region 9, the resulting comb design realizes a good thermal separation of the coolant circuit 1 from the refrigerant circuit 2.

[0032] According to Fig. 7 a three-dimensional view of another advantageous embodiment is proposed and in which the combination of different geometries of refrigerant and coolant tubes 7, 6 is elucidated. Two layers, or rows, of coolant tubes 6 are arranged after each other in direction of the passing air. Within one layer of coolant tubes 6, alternating refrigerant tubes 7 are arranged, whereby the refrigerant tubes 7 again are arranged in two layers after each other in direction of the passing air.

[0033] The heat exchanger unit of the refrigerant, which is integrated into one row of the coolant heat exchanger, can be placed on the air inflow side or air outflow side depending on the chosen configuration of additional heating by the refrigerant circuit.

[0034] Further, concerning the arrangement and type of coolant circuits, known in the state-of-the-art for cross flow, cross countercurrent flow and cross co-current flow as well as parallel flow and co-current flow can be used advantageously depending on the thermal states and space conditions.